Self-locking Fasteners

The Space Shuttle Main Engines (SSME) generate some 400,000 pounds of thrust and are subjected to tremendous vibration during the launch phase of a Shuttle flight. It follows that the fasteners—nuts and bolts, for instance—that attach joints, brackets, tube clamps and other parts must be capable of withstanding severe stress and vibration, and they must also be capable of repeated reuse, as is the SSME. Each SSME now uses 757 Spiralock™ fasteners made by Kaynar, a division of Microdot Aerospace Fastener Systems, Fullerton, California. These fasteners offer a number of technical advantages over the fasteners they replaced, in particular improved stress/vibration resistance and a 50-cycle reuse capability, where prior fasteners were good for only 15 cycles.

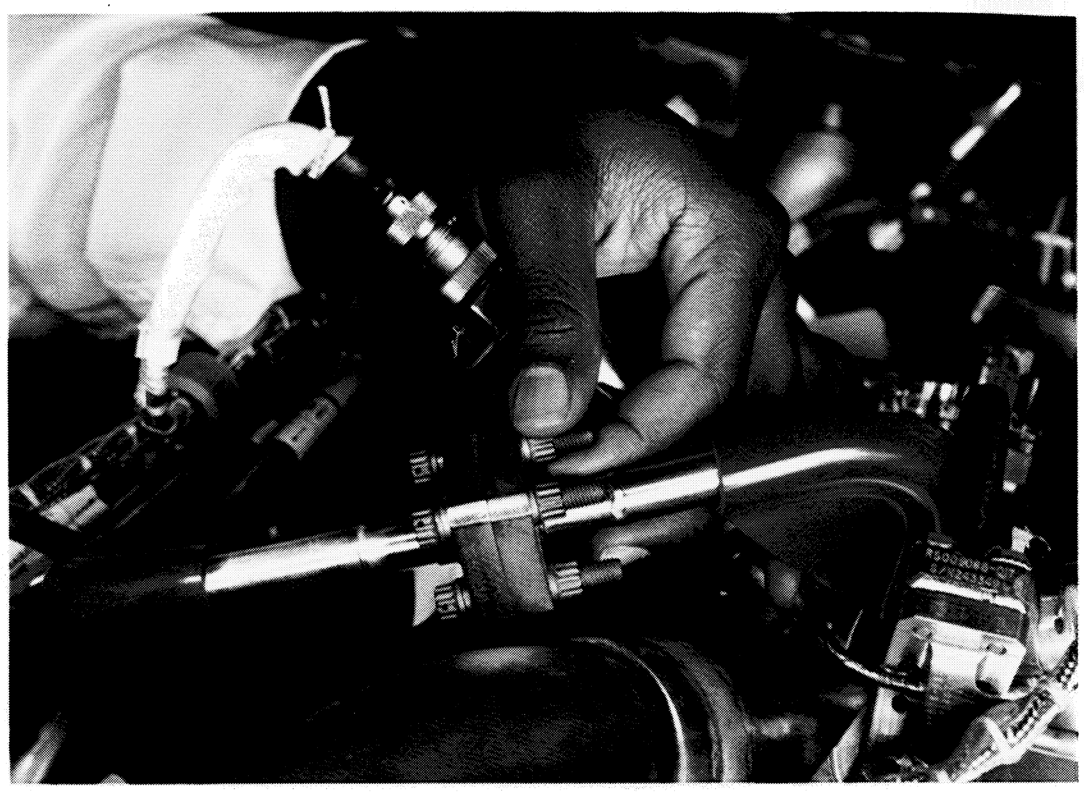
Spiralock is a fastener thread form invented by Horace Holmes of Holmes Tool Company, Walled Lake Michigan, and licensed to Kaynar Microdot and to Detroit Tool Industries, Warren, Michigan, which manufactures a Spiralock threading tool. Holmes set out to solve a major industrial problem, the matter of fasteners coming loose under vibration. Loosening is caused by vibration-induced lateral movement between the flanks of the bolt and nut threads; this lateral movement releases the locking friction that holds the joint together.

The Spiralock solution is a uniquely-designed female thread form which, used with male fasteners of standard thread form, provides a self-locking action that prevents the lateral movement and thus makes the threaded joint highly resistant to the effects of vibration. Additionally, thread contact runs the entire length of the nut, offering greater stress resistance than earlier fasteners.

Spiralock is not a conventional type of spinoff, because it is not based on NASA technology. It is, however, an example of technology transfer in that NASA's exhaustive testing of Spiralock for Shuttle use, and the resulting analyses and reports, made an important contribution to greater industry understanding of the complexities of fastening mechanical devices. The contribution is credited in particular to James J. Kerley of Goddard Space Flight Center for his extensive research on the self-loosening fastener problem, in which he was aided by Northrop Services test engineer Carol Jones. Kerley served for several years with the American Society of Mechanical Engineers (ASME) Subcommittee on Loosening Mechanisms of Bolted Joints Under Vibration. At Goddard, Kerley and the Structural Dynamics and Electromagnetic Test Section conducted comprehensive tests of Kaynar Microdot Spiralock nuts and several types of bolts under most severe vibration. The tests demonstrated that the fasteners would not "back off," or loosen, even when vibrations were applied 10 times as strong and 10 times as long as Space Shuttle specifications. Kerley's work, which went beyond Spiralock nuts and examined in depth the factors involved in generic fastener failure, was described by P.P. Zemanick, chairman of the ASME subcommittee, as "a valuable block of research into the phenomenon of threaded fastener self-loosening in a vibratory environment."

The Spiralock thread form has found wide acceptance in applications where fasteners are subjected to heavy vibrations and it has proved a problem-solver for many firms. An example is the experience of Chevron U.S.A.'s West Texas Production Division. At upper left is an oil production site beside which J. R. Butter, a Chevron production foreman, is holding a Spiralock rod coupling. On four wells, rod string failures were occurring two to three times a year. Each failure required pulling the rod string up to the surface, at a cost of

$1,000-2,000 per occurrence plus, typically, replacement of three to five couplings and rods.

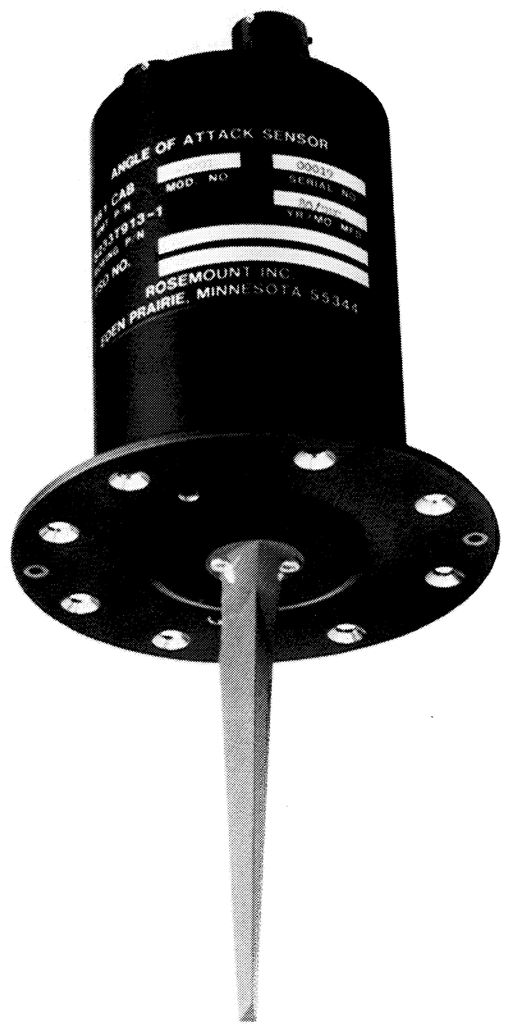


Butter decided that the fault was in the stress concentration of the threads of the standard type of rod coupling. He substituted Spiralock couplings, mated to the same type of rods previously used, on the four problem wells. After the strings had been down for a year, no failures of any type had been experienced; according to Butter, at least one and probably all four strings would have failed within the year if standard rod couplings had been used.

At left below is a truck-mounted seismic vibrator, manufactured by Litton Resources Systems, Alvin, Texas, used to generate subsurface ground vibrations for oil exploration and other geophysical investigations. Reliability of the vibrators was substantially improved by substitution of Spiralock for standard thread joints and fastener failures in field operations were sharply reduced.

Another application is illustrated at right, an angle-of-attack sensor used in the Boeing 757 and 767 jetliners. The sensor continually measures the angle between the chord—the fore to aft line—of the jetliner's wing and the direction of the airflow; the monitored data provides warning of impending stalls and also helps enhance fuel economy. Produced by Rosemount Inc., a subsidiary of Emerson Electric Company, Minneapolis, Minnesota, the sensor employs about 50 Spiralock fasteners to insure reliability in the severe stress and vibration environment in which the system operates. Additionally, use of Spiralock simplifies maintenance by negating the need to stock special types of fasteners earlier used and by eliminating special assembly procedures.

In addition to these examples, the Spiralock thread form is used in such diverse applications as intercontinental missiles, military fighter aircraft, automobiles and trucks. A closeup of an automotive application is shown in the top photo. ▲



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